Social organization and habitat use of introduced populations of the Vole *Clethrionomys rufocanus* (Sund) in Central Finland

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Abstract

Grey-sided voles *(Clethrionomys rufocanus)* from northern Finland were introduced on two islands of the Lake Konnevesi in 1983. The islands were emptied of local rodents before the introduction took place.

One of the populations died out due to predation by stoats *(Mustela ereminea)* already during the first summer. The new population introduced in autumn either didn't survive over the next winter. The island was recolonized by the bank vole during next summer.

The other population on an island of 1.7 hectares survived from summer 1983 until 1986 and reached a peak density of 69 individuals in August 1985.

The immigrant bank voles were not able to establish a population during the presence of grey-sided voles.

The voles preferred moist oligo-mesotrophic habitat with hummocs of *Ledum palustre* together with *Vaccinium myrtillus* and *V. uliginosum*. This habitat is characteristic to northern Finland.

In summer the breeding females were mutually amicable but territorial. Mature males behaved mutually aggressive but were not strictly territorial.

Contrary to the north Finnish populations the introduced voles aggregated on most suitable overwintering habitats. In spring there were lots of signs of foraging on those areas.

Dispersal of the voles to neighbouring islands was also observed.

Characteristics of the social organization and habitat preference of the introduced populations are compared with other populations. The social organization of this population was quite flexible, too.

Introduction

The social organization is studied from two points of view: 1. has it something to do with cycling of some small rodent populations or 2. is the social system a stabilizing factor in the population during all phases of a possible cycle (Viitala et al. 1986). The ways of studying these problems are either experimental manipulation of populations, long term survey of natural populations, or both.

In 1982 we started an enclosure study on social organization of bank vole (*Clethrionomys glareolus* Schreber) in Konnevesi Central Finland. The study has been going on since then and the first results have been reported by Ylönen and Viitala (1985) and Ylönen et al. (1986). The work was inspired by the study on social organizations of subarctic populations of the voles *Clethrionomys rufocanus* (Sund) and *Microtus agrestis* (L.) by Viitala (1977) in Kilpisjärvi, Finnish Lappland where distinct differences have been found concerning social organization and social population regulation between these species that adapted to different habitats (c.f. Viitala and Hoffmeyer 1985; Viitala et al. 1986). This forced us to try to introduce populations of grey-sided voles in Central Finland as control populations for the local bank vole populations in a long-term study on social organization.

The introduction could give information on influence of latitude and different environmental conditions on forming of social organization and on possible changes in competi-

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tive situation between rodent species in new environment (Henttonen et al. 1977; Hansson 1974). It could also clarify factors determining geographical distribution of *Clethrionomys rufocanus,* which just in the lowland of Fennoscandia and Sovjet Union is rather curious (Henttonen and Viitala 1982; Stenseth 1985).

Study area

Konnevesi Research Station is situated in northern Central Finland (62°15′N, 26°26′E) and it lies about 250 km from the nearest northern and eastern ranges of *C. rufocanus* (Fig. 1).

After two unsuccesful introduction trials in 1981 (c.f. Viitala et al. 1986) and 1982 study populations could be founded on two islands of the Lake Konnevesi in summer 1983.

Both islands Siimarinsaari (1.3 ha) and Iso-Korppi (1.7 ha) show the same main habitats (Fig. 2). The middle parts of the islands are higher and more oligotrophic than the brims. Both grow forest with either *Picea abies* and *Betula pendula* or *Pinus silvestris* as main trees. On Iso-Korppi *Populus tremula* is also common. The field layer is built up mainly by *Vaccinium myrtillus* or *V. vitis-idaea.* Parts of the field layer are almost free of vascular vegetation because of strong shading effect of spruce forest.

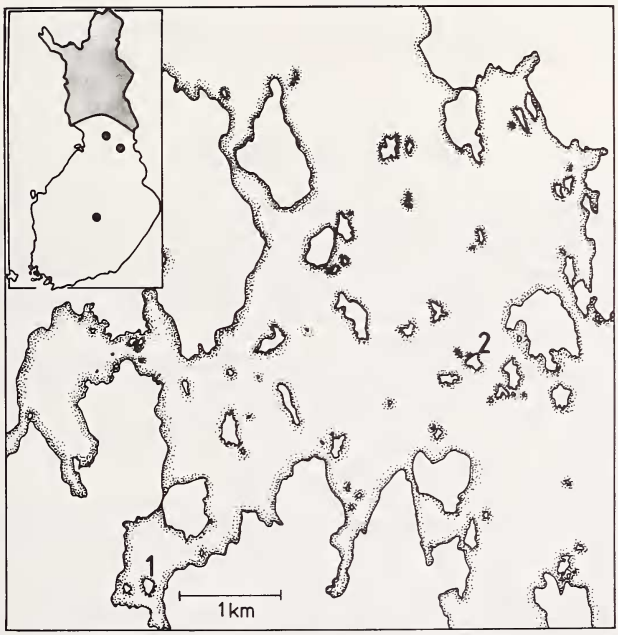

Fig. 1. Study area with the islands with introduced populations of the vole *Clethrionomys rufocanus* and the map of the distribution of the species in Finland. Also the location of the study site in Konnevesi, Central Finland is given. 1 = Siimari-Island, 2 = Iso-Korppi

The brims of the islands are oligo-mesotrophic, partly paludified heath forest with the same tree species as the middle parts. The field layer is dominated by kneehigh brush of *Ledum palustre, Vaccinium uliginosum* and *V. myrtillus.* The ground is a mosaic of brushy hummocs and depressions free of vascular plants between them. This vegetation type appears normally in northern Finland.

Siimarinsaari is a bit smaller and higher and that is why the vegetation belt dominated by *Ledum-Myrtillus* brushes on the brims is smaller than on Iso-Korppi. Siimarinsaari at the head of a bay has the minimum distance of 120 meters to the mainland. Iso-Korppi lies 220 meters from the nearest small island and more than 1.5 km from the mainland.

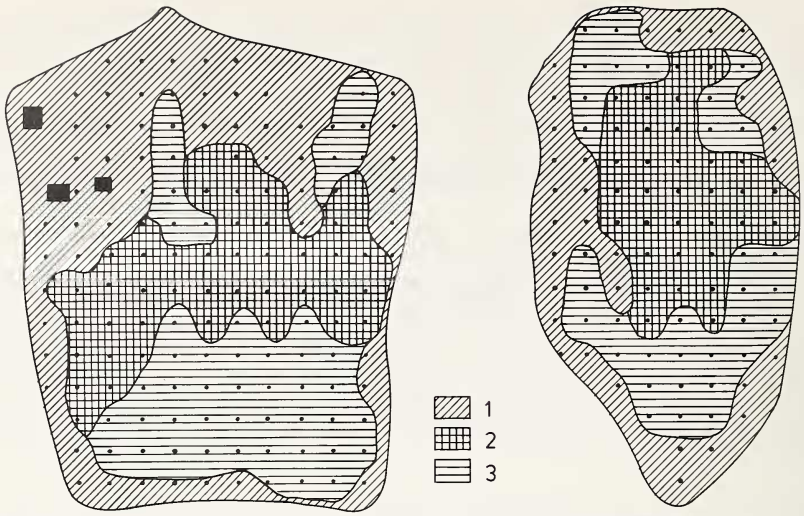

Fig. 2. Vegetation of the study islands. 1 = *Ledum-Myrtillus* bruhes, 2 = Fresh spruce and decidous forest with mainly *Vaccinium myrtillus* field layer, 3 = dry pine forest with *Vaccinium vitis-idaea*

Material and methods

The small mammal communities on the islands before the freesetting of grey-sided voles consisted of *Clethrionomys glareolus, Micromys minutus, Sorex araneus* and *S. minutus*. These species were captured by snaptrapping before introduction of *C. rufocanus* or later during live trapping.

The islands were covered by a grid of trap stations with ten meter intervals. On Iso Korppi the traps on each trap line were set at 20 meter intervals. On Siimari island and Iso Korppi 96 and 76 live traps of Ugglan Special type (Hansson 1967) respectively were set. On Iso Korppi each trap station had a trap for half of the total trapping time.

The trapping periods lasted five days and the traps were checked ten times each period. The islands were trapped once a month from July to October in 1983 and from May to October in 1984. In 1985 we were able to trap Iso Korppi in June, August and October.

Following observations were made every time an animal was captured: trap locality, time, species, individual identity, sex, sexual status, body weight, infestation by ticks, scars and possible other signs of aggression and behaviour of the animal(s) in the trap.

In October 1985 and June 1986 some snap and live trapping was done on the neighboring islands to determine dispersal of *C. rufocanus*. The existence of *C. rufocanus* can be seen the basis of typical feeding places, too, i.e. heaps of sticks of blueberry stems under natural covers and hollows – often also in live traps.

To determine possible changes in food preference of the grey-sided vole between its native and introduction area all possible information on foraging habits were noticed during the study periode. In spring 1986 after the snow melt winter foraging remains were collected around every trap station.

Results

Population fluctuations

We released three males and three females of *C. rufocanus* on Siimari island at the end of June 1983. Altogether 19 individuals were captured 72 times until the beginning of September. Then the whole population was killed apparently by a single stoat, *Mustela erminea*. Reintroduction after the removal of the stoat was unsuccesful and the island was recolonized by the native *C. glareolus*. Already in the beginning of June 1984 24 male and 27 female bank voles were captured on the island concentrating on brims.

Four females and three males were released on Iso-Korppi island in June 1983. During that summer 36 individuals were marked. The density was at highest in September: seven females and thirteen males (Fig. 3). Only one female and three males survived through the winter. The population recovered well in 1984, however, and after good winter survival it grew to 67 individuals (39 ind./ha) in summer 1985. In August twelve females and four males from the population were introduced on another, a little bit larger island to save the population after the possible winter collapse on Iso-Korppi. In May 1986 only a single male was found and the population of *C. rufocanus* was lost.

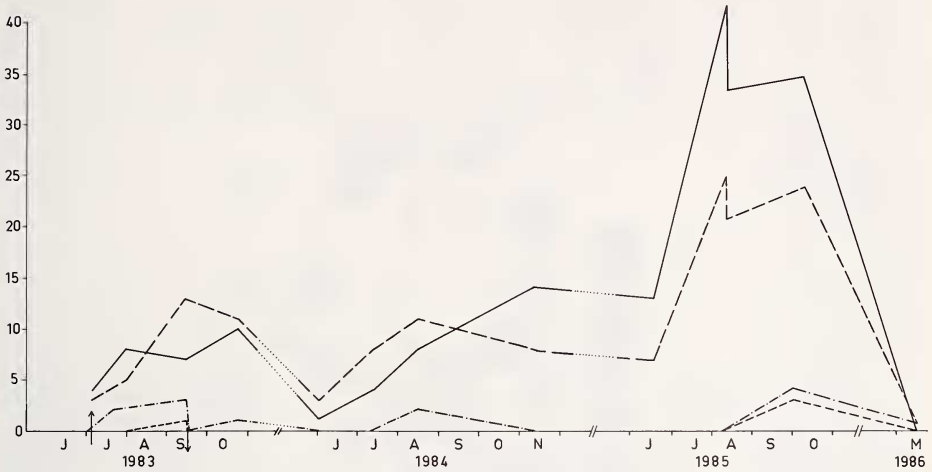

Fig. 3. Population fluctuations of *C. rufocanus* on Iso-Korppi between 1983 and 1986. Introductions or removals of voles are shown with arrows. Also the amount of immigrant bank voles is given. Solid line = females, broken line = males

Late summer every year individuals of *C. glareolus* were immigrating the islands populated by *C. rufocanus*. They were unable to occupy the most favored brim areas. None of them were able to survive through the winter.

Habitat preference

Both introduced animals and their offspring were captured almost without exception on the *Ledum-Myrtillus* belt of the brims and on other moist habitats with rich undergrowth (Fig. 4). The rather dry inner parts of the islands covered by pine and spruce forest with sparse field layer were avoided by *C. rufocanus*. Only the few immigrant bank voles, *C. glareolus*, were forced to use these areas. In the absence of *C. rufocanus* in 1984 on Siimari Island *C. glareolus* also preferred the moist *Ledum-Myrtillus* areas (Fig. 4). There were no significant differences in habitat use of *C. rufocanus* between seasons and years (Table 1).

Social organization

The number of breeding females did not exceed five on Iso-Korppi during the two first study years (Fig. 5). The number of mature males varied between two and four. As in previous studies (c.f. review by Viitala and Hoffmeyer 1985) females were mutually tolerant but mature and submature males were highly aggressive towards each other.

After high winter survival ten females were mature already in mid of June 1985. Only one trap was visited by two different breeding females even though home ranges of these

Table 1

Percentual use of the trapstations of different habitats during the study years 1983–1985 on Iso-Korppi

N shows the amount of captures in that year. All differences are significant with $p < 0.001$

Habitat / Traps / Year	*Ledum-Myrt.* 52	*Myrtillus* 42	*Vitis-idea* 47	n	
1983	65.6	21.3	13.0	169	$\chi^2 = 63.289$
1984	60.3	17.2	22.4	116	$\chi^2 = 28.765$
1985	54.7	26.9	18.4	234	$\chi^2 = 38.631$
Σ	59.5	22.9	17.5	519	$\chi^2 = 120.129$

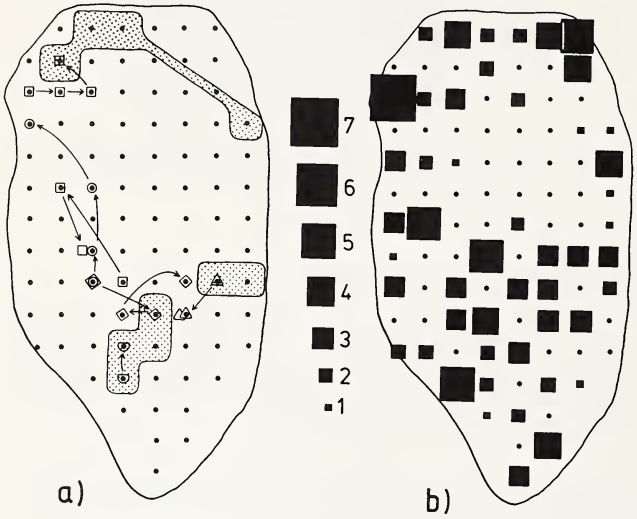

Fig. 4. Movements of the small population of *C. rufocanus* on Siimari-Island in July/August 1983 (a) and the frequence of trap visits by *C. glareolus* in August 1984 (b) after the recolonization of the island by the species. The figure shows the similar habitat use of the two species without competition

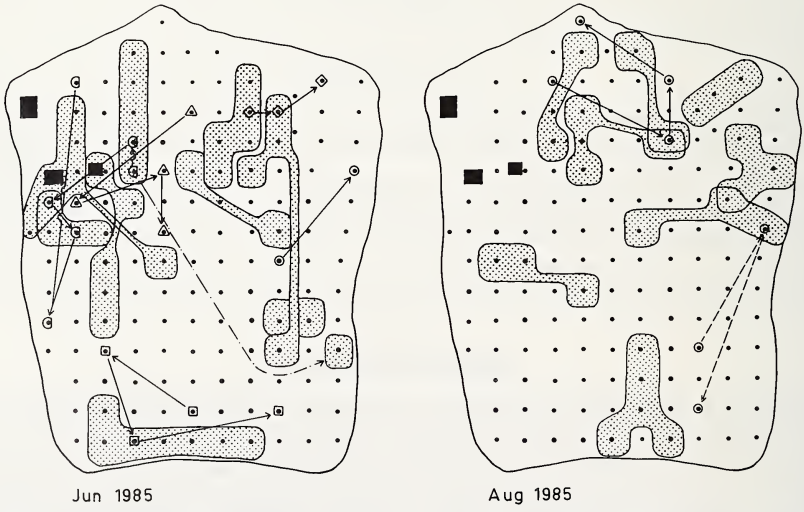

Fig. 5. Home ranges of mature females and movements of mature males of *C. rufocanus* on Iso-Korppi in June and August 1985

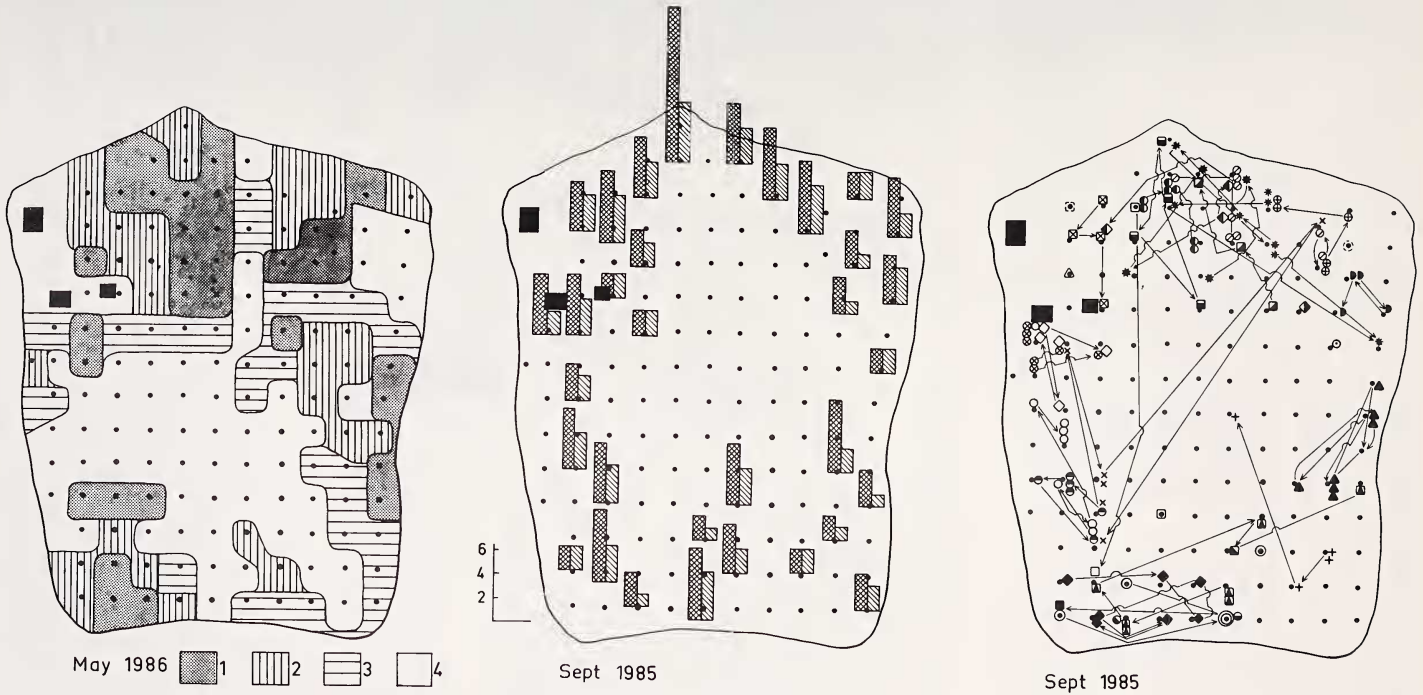

Fig. 6. Movements of the female grey-sided voles and the trap visit frequency of the population during the last autumn trapping in 1985, and the distribution of overwintering signs in spring 1986 just after the snow melt. The trapping frequency of each trap station with more than two visits (cross shaded columns) and the number of individuals which have visited these traps (single shaded columns) is shown. The number of captures in traps used by two or more individuals was 88 % of the total. The signs of overwintering was determined around every trap station and classified in four cathegories where 1 = very much remains of blue- and bilberry fed during winter by the voles . . . 4 = no signs of overwintering. The trapping results show an increasing use of single traps by several individuals and decrease of intraspecific avoidance of mature animals also. Together with the cumulation of overwintering signs we conclude that the population aggregated for the winter time in the *Ledum-Myrtillus* habitat. (See also table 2)

Table 2

The distribution and amount of food remains collected by the grey-sided vole in different habitats

The detected storages in the 10 × 10 m area around the trap station form a single sample. Dry weight in grams (W) of the stored plant material found in May 1986 is given. The group "others" consists of annual shoots and leaves of *Betula pendula, Picea abies, Pinus silvestris* and *Populus tremula*, which occured ocassionally in the samples. The amount of trap stations in each habitat is given in table 1

Habitat and the amount of samples	*Vaccinium myrtillus*		*Vaccinium vitis-idaea*		*Ledum palustre*		"others"		
	W	%	W	%	W	%	W	%	Σ
Ledum-Myrt. (24)	120.33	50.7	73.72	31.1	33.24	14.0	10.04	4.2	237.33
Myrtillus (9)	26.38	43.4	31.91	52.5	0.52	0.9	1.93	3.2	60.74
Vitis-idaea (6)	11.12	27.9	23.38	58.6	–	–	5.39	13.5	39.89

females covered big areas. Thus they were strictly territorial. In August there were eight breeding females behaving in the same way (c.f. Fig. 5). Also the number of mature males in June was twice as high as in previous summers. This resulted in very much aggression between them. Fresh wounds were noticed in every trapping day. In August 1985 there were only two mature males left. Males moved on larger areas than females.

Territorial behaviour begun to decrease towards autumn. The number of trap stations visited by several different individuals whether mature or not was increasing. In October distinct aggregations were recognized (Fig. 6).

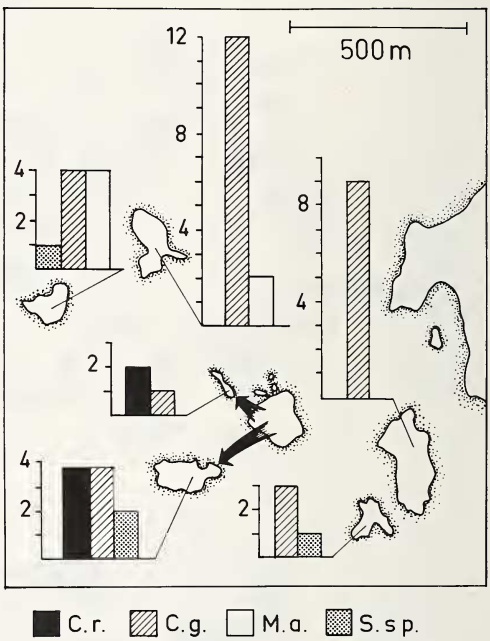

Fig. 7. Dispersal of grey-sided voles to the neighbouring islands during the late summer 1985. The graphs show the amount of voles and shrews captured in 100 trap nights. The arrows show the dispersal of grey-sided voles

Overwintering

The survival of the population was very low in the first winter and there were very little signs of winter foraging. Next winter 1984/85 the survival was about 90 percent for both sexes (s. Fig. 3). Already the autumn trapping gave the impression of aggregation formation. The signs of winter foraging cumulated also on the southern but especially northern brim parts of the island (Fig. 6). The big population going to overwinter in autumn 1985 seemed to form distinct aggregations in late September. Even though the population died out probably in late winter – early spring, the foraging signs concentrated on the sites of the aggregations.

The preferred food, collected in heaps typical for *C. rufocanus* in winter, were *Vaccinium myrtillus,* but also in great amount *V. vitis-idaea. Ledum palustre* and annual shoots of local spruce, pine and deciduous trees were also found in the heaps (Table 2).

Dispersal

Dispersal of *C. rufocanus* was evidenced by snap trapping on two nearby islands a small one 70 m from Iso-Korppi and a little bigger one 200 m from Iso-Korppi. On four more islands 400 to 600 m away (Fig. 7) *Microtus agrestis* and *C. glareolus* only were captured. Small heaps of blueberry stems and branches of willows out by voles were found on three of these islands probably indicating unsuccessful attempts of *C. rufocanus* to colonize these islands.

Submature bank voles were immigrating Iso-Korppi every year in late summer. They did not survive through winter, however. Not a single individual of *M. agrestis* was ever observed on the islands populated by *C. rufocanus* even though field voles are numerous on the other islands of the lake Konnevesi.

Discussion

The attempt to introduce *C. rufocanus* on central Finnish mainland enclosure was unsuccessful (Viitala et al. 1986). Also the first introduction attempts on islands failed because of poor habitats or predation by Mustelids. According to Oksanen and Oksanen (1981) one stoat or weasel is enough to destroy the whole population on such an island as we used in our study. Also on Iso-Korppi a stoat was observed in August 1984. It caused a decline of the population but not its total destruction. It is possible that the crash during winter 1985/86 have been due to predation. There were lots of Mustelids in Konnevesi area during the crash after two high density years of small rodents.

The decline of the population must have happened during late winter or early spring. That was indicated by the big heaps of blueberry stems (c.f. Table 2) with also fresh cuttings used as winter food. The single male captured in May 1986 was in very poor condition. The reasons of the crash are out of scope of the present paper, however.

The populations of small rodents on rather small islands must often be founded by immigrants allmost every year (c.f. Pokki 1981). The reasons of extinctions may be predation, hard climatical conditions and shortage of food.

The population colonized foremost the brims of the islands with rich growth of *Ledum palustre* and *Vaccinium myrtillus*. These areas with rocks and hummocs provide food and shelter. Nesting holes are important, because according to Henttonen and Viitala (1982) grey-sided vole is not able to dig very well. Dry mossy areas preferred by it in northern Finland (Kalela 1957; Kalela et al. 1971) do not exist on these islands.

Also bank voles preferred the same brim areas on Siimari-Island 1984 in the absence of *C. rufocanus*. The immigrant bank voles on Iso-Korppi were captured with only one exception in the dryer middle parts of the island. Presence of *C. rufocanus* obviously forced it to use poor habitats where it did not have the possibility to overwinter. In northern Finland *C. rufocanus* is stronger in interspecific competition of these two species (Henttonen et al. 1977). Hansson (1974), however, assumes that in areas, where *C. rufocanus* is on the southern border of its range *C. glareolus* could be in competitive advantage because it is very numerous on those habitats expectedly preferred by *C. rufocanus*. In the present island study this could not be the case because the few individuals immigrating the island were not strong enough to survive over the winter. The immigration of the submature bank voles took place in so late summer that the immigrants did not breed anymore – probably also due to interspecific inhibition (Kaarsalo and Wallgren

1985). The recolonization of Siimari-Island by *C. glareolus* after the disappearence of grey-sided voles was very successfull.

The immigrant bank voles entering the island must have swum at least the distance of 200 metres from the nearest neighbouring island. There are some unpublished observations on swimming ability of *C. rufocanus* during lemming migrations (Henttonen unpubl.; Kaikusalo unpubl.; Viitala unpubl.). During the present study they had evidently swum at least 200 metres. Some signs of blueberry storages were found also on two islands about 500 metres north from Iso-Korppi. No direct evidence by trapping exist, however.

Interesting ist the total absence of *Microtus agrestis* on the islands colonized by grey-sided voles (c.f. Viitala 1977; Henttonen et al. 1977) although the field vole was the most numerous rodent species on the neighbouring islands. Usually *M. agrestis* is much a more efficient colonizer than any of the *Clethrionomys* species (Viitala 1977; Pokki 1981).

The social structure of the breeding colonies of the introduced *C. rufocanus* colonies were the very same observed in other wild *Clethrionomys* populations (for review s. e.g. Viitala and Hoffmeyer 1985; Viitala et al. 1986) i.e. strict territoriality of mature females and overlapping of much larger home ranges of mature males.

Contrary to the observations of Viitala (1977) and Henttonen and Viitala (1983) in northern Finland the island population of *C. rufocanus* aggregated during winter in Middle-Finland. The population on Iso-Korppi behaved similarly as the mainland population of *C. glareolus* native to the area (Ylönen and Viitala 1985). The flexibility of the overwintering strategy of *C. rufocanus* is suggested already by Viitala and Ylönen (1985). Heat saving by aggregating seems to be especially advantageous on the islands where the snow cover is eaven thinner than on the mainland of Central Finland. This kind of behaviour may, however, increase small Mustelid predation, and cause population crashes described also in the present study.

The small introduced *C. rufocanus* populations on the islands or on mainland in Central Finland had the dangers of founder populations (McArthur and Wilson 1967; Diamond 1984). They may die because of environmental or endogenous reasons or by accident. All our study population died out during the five years study. Some new populations – still unknown for us – may have been founded by dispersers. According to Pokki (1981) only one pregnant female is enough to found a new island population.

Acknowledgements

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Zusammenfassung

Soziale Organisation und Habitatpräferenz von Clethrionomys rufocanus-Populationen in Mittelfinnland

Graurötelmäuse, *Clethrionomys rufocanus* (Sund), aus Nordfinnland wurden auf zwei Inseln des Sees Konnevesi (Mittelfinnland) im Sommer 1983 eingebürgert. Vor der Einbürgerung wurden die heimischen Nager der Inseln mit Schlagfallen abgefangen.

Eine der Populationen wurde schon während des ersten Sommers durch ein Hermelin *(Mustela erminea)* zerstört. Die im Herbst neu eingebürgerte Population überlebte den folgenden Winter auch nicht. Die Insel wurde im nächsten Sommer durch Rötelmäuse *(Clethrionomys glareolus)* sehr schnell wieder kolonisiert.

Die andere neu gegründete Inselpopulation konnte sich vom Sommer 1983 bis Frühjahr 1986 erhalten und erreichte im Spätsommer 1985 die höchste Dichte von 69 Individuen auf einer Fläche von 1,7 ha.

Die auf die Insel immigrierenden Rötelmäuse hatten keine Möglichkeit, während der Anwesenheit der Graurötelmaus eine Population zu stabilisieren.

C. rufocanus bevorzugte feuchte Habitate, die ein Vegetationspolster von *Vaccinium myrtillus,*

Ledum palustre und *Vaccinium uliginosum* aufwiesen. Diese Habitate sind charakteristisch für Nordfinnland.

Während des Sommers lebten die reproduktiven Weibchen territorial. Geschlechtsreife Männchen waren während der Reproduktionsperiode untereinander sehr aggressiv.

Im Gegensatz zu nordfinnischen Populationen verbrachten die eingebürgerten Graurötelmäuse den Winter im sozialen Verband in den Vorzugshabitaten. Anzeichen der gemeinsamen Überwinterung waren nach der Schneeschmelze reichlich vorhanden.

Abwanderungen von Graurötelmäusen auf Nachbarinseln wurden auch nachgewiesen.

Die soziale Organisation sowie die Bevorzugung bestimmter Habitate durch die eingebürgerte Population wird mit anderen *Clethrionomys*-Populationen verglichen. Die eingebürgerten Graurötelmäuse zeigten, wie schon für andere *Clethrionomys*-Arten nachgewiesen, eine flexible soziale Organisation.

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